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CITRUS TRISTEZA VIRUS AND ITS VECTORS IN FLORIDA

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Citrus tristeza virus (CTV), the most economically important viral disease of citrus in the world (1), was first diagnosed in Florida in 1952 (14). However, considering the free-flow of citrus budwood prior to the formation of the Budwood Registration Program, it was probably introduced much earlier (4). CTV, a closterovirus, has flexuous rod-shaped particles and is essentially phloem limited in plants (2). Its host range is restricted to the Rutaceae including most varieties of citrus (2). Because CTV is readily graft-transmitted and is spread in nature by aphid vectors it has become widespread in Florida. Florida traditionally has had mild CTV isolates. Most commercial cultivars of citrus infected with these mild CTV isolates are symptomless except limes. CTV problems in the past have been only sporadic, however, during the past several years, an alarming number of citrus trees on sour orange rootstock, (Citrus aurantium L.), in central and south Florida (Fig. 1) have declined quickly and died within several months of first symptom expression due to CTV (4,10). Thousands of young nursery trees on sour orange rootstock have also failed to attain normal growth rates (4). While established isolates of CTV are problematic for Florida's citrus industry, there are even more destructive CTV isolates present in other major citrus-growing areas worldwide (3). These exotic CTV isolates cause a serious stem-pitting disease in susceptible citrus cultivars regardless of rootstock (Fig. 2), and pose a threat to the Florida grapefruit industry (14).

Another threat is the exotic brown citrus aphid, Toxoptera citricida (Kirkaldy), (Fig. 3). This is the most efficient aphid vector of CTV and its introduction into Florida could have an impact on citrus production because severe isolates of CTV would be more easily spread (1,15).

Fig. 1. Valencia orange on sour orange rootstock showing quick decline in Florida. The latency period and rate of decline are affected by environment, by host species, and by the severity of the virus isolate. Photo courtesy of S. M. Garnsey.

Fig. 2. Severe stem pitting causing a bumpy or ropy appearance on trunk of Marsh grapefruit in Africa. This isolate does not occur in Florida. Photo courtesy of S. M. Garnsey.

Fig. 3. Toxoptera citricida on sweet orange in Hawaii (left) and South Africa (right). Populations are heavy on citrus. This aphid does not occur in Florida.

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VIRUS TRANSMISSION AND VECTOR BIOLOGY: CTV is transmitted in a semipersistent manner (17) by several aphid species in Florida. The most efficient vector in Florida is the melon aphid, Aphis gossypii Glover (19). The spirea aphid, A. spiraecola Patch (formerly A. citricola Van der Coot) (9) transmits CTV with less efficiency but its enormous numbers on citrus in relation to the melon aphid suggests that the spirea aphid may be as important as the melon aphid in the natural spread of CTV. Field spread of CTV is primarily by winged aphids. Once infected, an aphid can only transmit CTV for a 24-hr period unless it acquires more CTV from an infected tree. During this period, the winged aphid can fly several miles or more from the CTV source. Non-winged aphids, in contrast, rarely move from the source plant from which they were born. Hence flightless aphids are not significant in CTV spread unless tree canopies touch. Natural spread of CTV is also affected by host variety. Temple orange (C. sinensis (L.) Osbeck hybrid) has frequent growth flushes which support high aphid populations (16,20), and it is a good host for CTV replication (13). This results in high inoculum and vector pressure, therefore, CTV problems in the vicinity of a Temple grove can be chronic. In contrast, grapefruit groves have lower aphid vector populations and grapefruit trees support erratic and lower replication levels of CTV (13).

Aphids develop only on new growth (flush) of citrus. Once a flush matures, it is no longer acceptable for aphids. In established groves, the flush periods generally coincide with spring, early summer, and fall seasons and the availability of moisture from rain or irrigation. In contrast, young groves and nurseries are more frequently irrigated and fertilized and, hence, flush continually. The spirea aphid has a wide host range and is, by far, the most abundant aphid on Florida citrus. Feeding by the spires aphid causes severe curling of the citrus leaf which is not symptomatic of CTV.

DISEASE DIAGNOSIS: CTV symptoms in Florida are diverse and are affected by virus severity, rootstock, and scion variety. CTV decline occurs when sweet orange, grapefruit or mandarin trees on sour orange rootstock are infected with a CTV isolate which induces phloem necrosis at the budunion. This causes a girdling effect and the tree declines as starch reserves in the roots are depleted. Other symptoms include leaf chlorosis, wilting, heavy fruit set, and destruction of feeder roots.

In Florida, CTV infected trees that decline slowly usually develop honeycombing symptoms (Fig. 4) which appear as a massing of numerous small pinholes on the inside of the bark just below the budunion (9). CTV isolates which cause severe stem pitting in grapefruit and sweet orange do not exist in Florida. However, *they* are common in many citrus growing regions in Asia, Africa, South America, and the Pacific basin. Symptoms include a bumpy or ropy stem appearance (Fig. 2), deep pits on branch and scaffold limbs, reduced fruit size and a lopsided tree canopy. These isolates are severe in grapefruit and should be kept out of Florida.

Fig. 4. In Florida trees, honeycombing which appears as a massing of numerous, small pinholes inside the bark just below the budunion, most often results from slow decline caused by tristeza. Photo courtesy of S. M. Garnsey.

Caution should be exercised in field diagnosis because decline symptoms can be associated with a number of diseases including foot rot and root rot, nematodes, blight, many other virus diseases, and water damage. CTV infection can also be diagnosed by serological tests (11), by graft inoculating an indicator plant such as Mexican lime, C. aurantiifolia (Christm.) Swingle, or by cytological examination of phloem tissue with Azure A for virus inclusion bodies (5). Differences in virus severity can only be determined by graft inoculation onto a host range (12).

VECTOR DESCRIPTIONS: Toxoptera aurantii (Fonsc.), the black citrus aphid, is separated from T. citricida by the branching of the median vein in the wing (Figs. 5 and 6). It has been reported to transmit CTV in India, but this has not been confirmed with Florida CTV isolates and T. aurantii populations. A key to all aphids on Florida citrus was published earlier (7).

The winged viviparous (giving birth to live young) form of T. citricida, the brown citrus aphid, has dark brown to black head, thorax, cornicles, and cauda. The cauda has 12 or more setae on each side. Antenna segments I, II, and III are dark brown to black, (Figs. 6 and 7) with 10 to 12 sensoria on III. Body length is 1.40 to 1.90 mm; hind tibia 1.10 to 1.50 mm; antenna 1.50 to 2.00 mm (8). This aphid is usually found on plants in the family Rutaceae. T. citricida occurs on citrus in Asia, Australia, New Zealand, the Pacific basin, Africa and South America. However, it does not occur in the continental **U**.S.

The alate (winged) viviparous form of A. gossypii, the melon aphid, is variable in body color (from whitish lemon-yellow to blackish green in different individuals often in the same colony). The cornicles are black and the cauda light to dusky with 2-3 short pairs of lateral setae that are acutely bent toward the cauda (Fig. 9). Antenna segment III with 3-12 sensoria; body length 1.1 to 1.8 mm; hind tibia .50 to .95 mm; antenna .65 to .80 mm (5 segmented occasionally rather than 6). The melon aphid has many host plants.

The alate viviparous forms of A. spiraecola, the spirea aphid, are all black on the head, thorax, cornicles, and cauda. Abdomen is light yellowish green with dusky lateral areas at base of each cornicle. The cauda has 5-6 pairs of setae (Fig. 10). The body is 1.20 to 1.70 mm; hind tibia .55 to .80 mm; antenna 1.10 to 1.13 mm. Antenna segments I, II, and III light to dusky; antenna segment III with 4-10 sensoria (Fig. 8). This aphid has a wide host range.

A Key to Alate Viviparous Female Aphids

1. Median vein branched once, body dark brown (Fig. 5).....Toxoaurantii*

   Median vein branched twice (Fig. 6) 2

2. Antenna segments I, II, and III dark brown (Fig. 7) .....Toxoptera citricida

   Antenna segments I, II, and III not dark brown (Fig. 8) 3

3. Cauda light to off white with 2-3 pairs of setae (Fig. 9) .....Aphis gossypii

   Cauda dark brown with more than 3 pairs of setae (Fig. 10) .....Aphis spiraecola

*Not confirmed as a vector of CTV in Florida, but is commonly found on citrus.

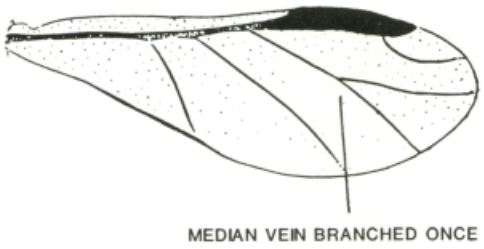

Fig. 5. Forewing of T. aurantii

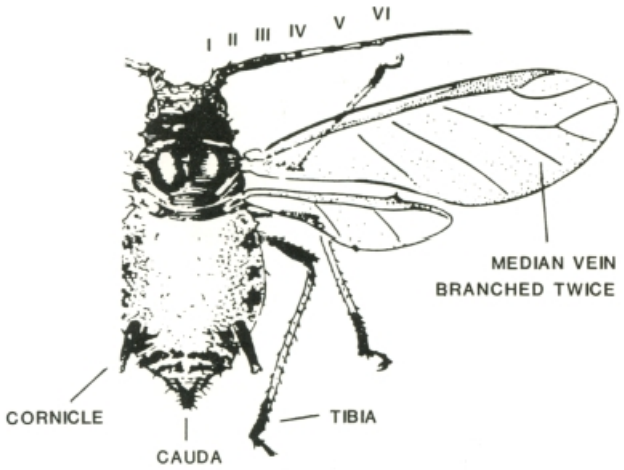

Fig. 6. Alate viviporous female

Fig. 7. Antenna of T. citricida

Fig. 8. Antenna of A. spiraecola

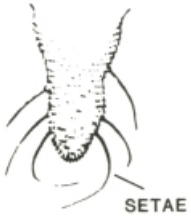

Fig. 9. Cauda of A. gossypii

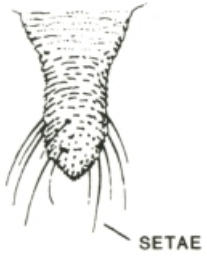

Fig. 10. Cauda of A. spiraecola

CONTROL: The most effective control for CTV is the use of tolerant rootstocks such as Cleopatra mandarin (C. reticulata Blanco) and Swingle citrumelo (Poncirus trifoliata Raf. X C. paradisi Macf.). Stem-pitting CTV isolates affect citrus scions regardless of rootstock and have only been controlled by the use of more tolerant scion varieties and mild isolate cross protection. Cross protection uses mild CTV isolates to protect against the effects of severe stem pitting isolates of CTV (6), and is used commercially in Brazil and South Africa.

Eradication of endemic isolates of CTV is not feasible in Florida since CTV is widespread, aphids are abundant and there are no geographic barriers to create CTV-free zones. Use of virus-free budwood would ensure no occurrence of CTV contamination by propagation. However, the large quantities of budwood required for this will not be available until fundamental changes are made in the Citrus Budwood Registration Program, Division of Plant Industry, Florida Department of Agriculture and Consumer Services (18).

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